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Individual learning as a function of the interstimulus interval in a delayed classical procedure.

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INDIVIDUAL LEARNING AS A FUNCTION OF THE INTERSTIMULUS INTERVAL IN A DELAYED CLASSICAL PROCEDURE

by

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ABSTRACT

This study investigated the effect of the interstimulus interval on level of learning and on response latency. A delayed classical procedure was employed.

The experimental group consisted of 42 male undergraduate, monolingual students. Seven interstimulus intervals were employed which ranged geometrically from 0.25 through 16.00 seconds. All interval groups were instructed to learn six random associations between six white lights and six response buttons. The level of learning was measured over test trials, and response latency over training trials.

Analysis of variance showed no overall significant differences in level of learning achieved for the seven interval groups. The overall increase found in response latency with increases in interstimulus time was statistically significant. In addition, the overall decrease in response latency as training progressed was significant.

The results were discussed in terms of mediation processes and contiguity theory. Further research employing different experimental procedures was recommended.

PREFACE

This study began one year ago when the author became interested in higher order individual human learning. Specifically, what is the effect on individual learning when the correct answer to a question is held back for different periods of time? Aside from the theoretical value of such research in the psychology of learning, it presents excellent opportunities for research in more applied but essential aspects of human behaviour such as learning in an elementary classroom situation.

I would like to express my gratitude to Dr. V. B. Cervin, my director whose suggestions for experimental design and his interest and enduring guidance made this paper a reality, and to Dr. Cervin, Dr. A. A. Smith and Mr. K. Kabisch who made the appartus available. I wish also to express my appreciation to my readers, Mr. M. Starr and Dr. E. Channen, for their cogent editorial criticisms; to Susan M. Scheich, my friend and laboratory partner who assisted in the experiment; to Katherine Ladd, my wife, who typed all revisions of the paper; to the subjects who so kindly participated in the study; and finally to Mark Ladd, my four year old son, who has kept me motivated throughout the study by asking every day "daddy, do you have to go back to school to work on your thesis tonight?"

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CHAPTER I

INTRODUCTION

In the framework of classical learning procedure there are numerous investigations relating the effect of the length of the time interval between the onset of a "neutral" stimulus (originally ineffective in eliciting the desired response) and the onset of an "original" stimulus (originally effective in eliciting the desired response), on the level of learning achieved and the response latency in individual human learning. All these studies have employed a negative (aversive, noxious) stimulus as the original stimulus. Kimble (1961, pp. 156-7, Table 13) summarizes the results of many of these investigations. Grant (1964) and Grings (1964) have given extensive reviews of studies employing positive as well as negative stimuli as the original stimulus. However, the studies using positive stimuli have generally been concerned with the classical procedure as such, and not with the interstimulus interval.

In the classical procedure an original stimulus ("UCS"), which reliably produces a desired response is paired with a neutral stimulus ("CS") until the neutral stimulus alone is capable of producing the desired response, or at least a response very similar to the one desired. The original stimulus has been defined most often as an "unlearned" stimulus that naturally (without learning) produces a desired response. It, can, however, be a "pre-learned" or "pre-instructed" stimulus, as in the present study.

Four temporal relations between the CS and the UCS have been studied. First, "backward" classical procedure is operationally defined as the situation in which the onset of the UCS precedes the onset of the CS. Second, "simultaneous" classical procedure is where the UCS and the CS are presented at the same time for equal specified intervals. Third, "trace" classical procedure is where the onset of the UCS follows the offset of the CS. Fourth, "delayed" classical procedure is where the onset of the UCS occurs some specified time after the onset of the CS, the two overlap in time and their offsets are simultaneous.

The question of which interstimulus interval in these experimental procedures leads to the most effective learning has long been the centre of interest in this active area of research. Virtually all investigators have reported that a delay of approximately 0.50 seconds between the onset of the neutral stimulus and the onset of the original stimulus produces the fastest rate and highest level of learning. On either side of this interval learning proceeded more slowly.

One major difficulty in evaluating previous investigations is the fact that some investigators have used two or more of the procedures described above in the same experiment ((Fitzwater and Thrush (1956), Spooner and Kellog (1947), Wolfle (1930, 1932)). Others employed only one procedure ((Kimble (1947), Kimble, Mann and Dufort (1955), White and Schlosberg (1952)). Thus comparison of results from experiments using different experimental procedures is questionable. In addition, no research other than that employing an oringinal stimulus of aversive quality has been reported for the relationship between the interstimulus interval and individual human learning. Except for one experiment by Rodnick (1937) there is, in the literature, no investigation studying the relationship of the maximum level of learning and response latency for interstimulus intervals greater than 4.00 seconds.

The present study employs the delayed classical procedure with informational reinforcement in an attempt to determine the effect of the length of the interstimulus interval on the level of learning and response latency in individual human learning. It is felt that the use of one experimental procedure will result in a more precise determination of the effect, on learning, of the interstimulus interval.

Review of the Literature

The present study is concerned primarily with individual human learning as it is affected by the length of the interstimulus interval in a delayed classical procedure. Accordingly only the literature pertinent to this problem and dealing with individual learning will be included in this review.

Studies of the effect of the interstimulus interval on the level of learning and response latency in individual human learning have been done almost exclusively on the eye-blink, finger- or hand-withdrawal, and galvanic-skin responses. The present discussion, then, can be divided conveniently into the following four parts: 1) areview of the studies on the finger- or hand-withdrawal response; 2) a review of the studies on the galvanic-skin response; 3) a review of the studies on the eyeblink response; 4) conclusions based on the results from these three areas of experimental investigation.

Finger- or Hand-withdrawal Response Studies

In this type of study the usual procedure is to pair shock, the original stimulus that dependably elicits the response of finger- or hand-withdrawal, with a neutral visual or audio stimulus for a specified number of trials or a given period of time. The level of learning is determined by the number of responses given to the neutral stimulus as a result of the pairing when the neutral stimulus is presented alone. Response latency is measured from the onset of the neutral stimulus to the onset of the response.

One of the first finger-withdrawal investigations on the effect of the interstimulus interval on learning was by H. M. Wolfle (1930). Interstimulus intervals of 0.00, 0.25, 0.50, 0.75, 1.00, 1.25 and 1.50 seconds were employed. Wolfle also tested two backward intervals of 0.25 and 0.50 seconds. She found that the maximum degree of learning was obtained when the interstimulus interval was 0.50 seconds in the forward procedure. Both longer and shorter intervals were less effective. Somewhat different results are to be found in a second study by Wolfle (1932), who, in a situation essentially the same as that employed in her earlier study, determined the optimal interval to be o.20 to 0.30 seconds. Both longer and shorter intervals were found to be less effective. In these two studies Wolfle did not report on response latency.

Similar results have been reported by Spooner and Kellog (1947) who obtained most effective learning at the 0.50 second interval. Employing the trace procedure, they used six interstimulus intervals; two backward intervals of 0.25 and 0.50 seconds, one simultaneous interval, and three forward intervals of 0.50, 1.00 and 1.50 seconds. Spooner and Kellog found that the three forward groups gave conventional negatively accelerated learning curves; with the 0.50 second interval approaching its maximum more rapidly than the other two intervals. Average response latencies of the forward intervals were directly related to the size of the interstimulus interval; i.e., as the interval increased, so did the response latency. In addition, they reported a gradual increase in latency within a given interval as the number of responses built up.

Fitzwater and Thrush (1956) attacked the interval problem by emphasizing the shapes of acquisition curves under various interstimulus intervals. They used one simultaneous interval and five forward intervals of 0.10, 0.20, 0.30, 0.40 and 0.60 seconds. The 0.20, 0.30 and 0.40 second intervals gave the usual negatively accelerated learning curve. The 0.00, 0.10, and 0.60 second acquisition curves were similar to the conventional extinction curves; i.e., where learning is at some level above zero in the initial phase of acquisition and then tends toward zero level in later phases. The rate of acquisition was fastest in the 0.40 second group, then in the 0.30 group, followed by the 0.60, 0.10 and 0.00 interval groups. The level of learning was highest for the 0.40 and 0.30 second intervals. Response latency was not discussed in this study.

In a study using forward classical procedure and using intervals of 0.02, 0.235, 0.44, 0.86, 1.05 and 1.25 seconds Jones (1961) obtained most effective learning at 0.235 seconds. She also found that the rate of learning for the shorter intervals was faster in the beginning of training and then fell off as training progressed, while the reverse of this was true for the longer intervals.

Galvanic-Skin Response Studies

The procedure for this type of study has been identical to that for the finger- or hand-withdrawal studies except that the response measured is the galvanic-skin response. The galvanic-skin response does have one advantage over the finger-withdrawal response; i.e., it is an involuntary response. Thus there is no possibility of voluntary responses being added to, or confused with, true learned responses.

In a delayed procedure with an interstimulus interval of 17.40 seconds Rodnick (1937) found that the response latency moved from 4.20 to 8.31 seconds during training. In a parallel experiment using a trace procedure with an interstimulus interval of 20.10 seconds, he found that the response latency moved from 4.40 to 10.10 seconds during training. He concluded that the reason for this increase in response latency may actually have been a moving back of the learned response to the point of reinforcement.

White and Schlosberg (1952), using a delayed procedure, worked with six interstimulus intervals, 0.00, 0.25, 0.50, 1.00, 2.00 and 4.00 seconds. The 0.50 second interval produced the highest level of learning. Learning tended to fall off rapidly on either side of this interval. The 0.20 second group showed a marked suggestion of inferiority to all other groups. These authors did not report on response latency.

In a trace procedure Moeller (1954) employed four interstimulus intervals, 0.25, 0.45, 1.00 and 2.50 seconds. The performance at the 0.45 second interval was superior throughout learning, followed by the 0.25, then the 1.00, and then the 2.50 second interval groups. The response latencies were not determined in this experiment. Jones (1961), in a similar experiment, reported optimal learning for the galvanic-skin response at the 0.44 second interval.

Eyeblink Response Studies

The experimental procedure for the eyeblink response experiment is to pair an air puff, the original stimulus that consistently elicits the eyeblink response, with a neutral visual or audio stimulus for a specific number of trials or a given period of time. The rate of acquisition and the level of learning are determined by the number of responses given to the neutral stimulus as a result of the pairing when the neutral stimulus is presented alone. Response latency is measured from the onset of the neutral stimulus to the onset of the response.

While varying the interstimulus interval from 0.630, 0.791, 0.996, 1.246, 1.570, 1.977 to 2.497 seconds during one experimental session on the same subjects, Prokasy, Ebel and Thompson (1962) found that the response latencies systematically lengthened with the increase in interval time. In addition, one control group was run with an interstimulus interval of 2.497 seconds. Another control group was run with an interstimulus interval of 0.630 seconds for the first four-fifths of training, and a 2.497 second interval for the last one-fifth of training. They found that the number of responses of the first control group was significantly less than for either of the other two groups. Further, as the interval was increased in the experimental group the frequency of response decreased. When the second control group was shifted from the 0.630 second interval to the 2.497 second interval an immediate drop in response frequency with no later increase resulted. These results point to the conclusion that rate of response decreases with increases in the interstimulus intervals. Response latency was not considered in this study.

In another trace procedure Kimble, Mann and Dufort (1955) in their first experiment employed interstimulus intervals of 0.50, 0.80, and 1.50 seconds. They found that the highest level of learning occurred for the 0.50 second interval and that amount of learning decreased with increases in the interstimulus intervals. The $F_{obs.}$ for this effect of the interval was significant at the 0.01 level. In this experiment response latency was not reported.

Employing a delayed procedure McAllister (1953) studied five interstimulus intervals, 0.10, 0.25, 0.45, 0.70 and 2.50 seconds. He found that the rate of acquisition grew systematically for each interval to its asymptotic level. As for the level of learning, the 0.25 second interval gave the greatest increase in performance level, followed by the 0.45, 0.70, 0.10 and 2.50 second intervals. The differences in the final level of learning were found to be significant between the 0.01 and 0.05 levels for the interval factor. The difference between the 0.25 and 0.45 intervals, however, were not reliable. Learning at the 2.50 second interval was markedly inferior to all other intervals. McAllister was not concerned with response latency in this experiment.

Kimble (1947) presented a further investigation using a forward delayed procedure that dealt with the rate of acquisition and level of learning. He used six inter-stimulus intervals, 0.10, 0.20, 0.225, 0.25, 0.30 and 0.40 seconds. Kimble found that the level of learning varied inversely with the interval; i.e., the highest level of learning was obtained by the 0.40 second interval and the least by the 0.10 interval. In addition, the rate of acquisition was found to be an increasing negatively accelerated function of the interstimulus interval. Kimble's study can be criticized for not testing intervals longer than 0.40 seconds to determine the effect on rate of acquisition and level of learning.

Conclusions Based on the Results of these three Areas of Investigation

The level of learning achieved varies with different interstimulus intervals. It systematically increases with increases in the interstimulus interval up to an optimum range, after which it falls off. The optimal interval range was found to be between 0.20 and 0.50 seconds. The 2.00 to 2.50 second interval appears to be measurably inferior with respect to rate of acquisition and level of learning when compared with other intervals.

From the studies concerned with response latency, it can be stated that response latency consistently increases with increases in the interstimulus interval. In addition, the response latency for any given interval increases with practice.

It must be remembered that these conclusions are based on responses where aversive stimuli were used as the original stimulus. In contrast, the present study is concerned with higher order learning using positive stimuli. These conclusions, therefore, cannot be used as a source of hypotheses for the present study. In addition, these conclusions can be considered in the light of the results of the present study only for purposes of contrast.

Purpose of the Present Research

The present investigation is directed as a precise determination of the relationship of maximum level of learning achieved in a given number of trials and response latency to the time interval between the neutral and original stimuli, when this interstimulus interval is varied from

0.25 to 16.00 seconds. This is a parametric study.

This research is considered in order for three reasons: 1) no research, other than that employing an original stimulus of aversive quality has been reported for the relationship between the interstimulus interval and individual human learning; 2) many of the previous studies have confounded the effects of the interstimulus interval by employing different experimental procedures in the same experiment; and 3) except for one experiment by Rodnick (1937) there is, in the literature, no investigation studying the relationship of maximum level of learning and response latency for interstimulus intervals greater than 4.00 seconds.

CHAPTER II

METHODOLOGY AND PROCEDURE

Subjects

The subjects were 42 male undergraduate students enrolled in elementary psychology courses at the University of Windsor. All subjects were monolingual as it had been determined in previous investigations by the writer and others that monolinguals learned more rapidly than bilinguals in this type of experiment with this apparatus. All subjects were naive as to the nature of the experiment and the apparatus previous to participation.

The 42 subjects were randomly assigned to seven groups of six each. The seven groups were, in turn, randomly assigned to the interstimulus intervals of 0.25, 0.50, 1.00, 2.00, 4.00, 8.00 and 16.00 seconds. The order in which the interval groups participated was randomized in order to normally distribute any temporal variation such as subject fatigue, experimentor bias and possible apparatus failure. During experimentation three subjects were disqualified and replaced because of a failure of the apparatus; and one subject was disqualified and replaced because of a misunderstanding of the experimental procedure. In addition, one subject in the original sample was replaced for refusing to participate. Experimental time for each subject varied between 30 and 45 minutes. The subjects were not reimbursed for participating in the experiment and were free to refuse. All subjects were contacted one day in advance of participation.

Apparatus

The General Learning Apparatus of the department of Psychology, University of Windsor was used. The apparatus consisted of six isolated panels arranged in a hexagon, and a master console located in a separate room from which all panels were automatically operated. Of the six panels A through F, panels A, B and C were used. A diagrammatic representation of panels A, B and C is presented in Figure 1.

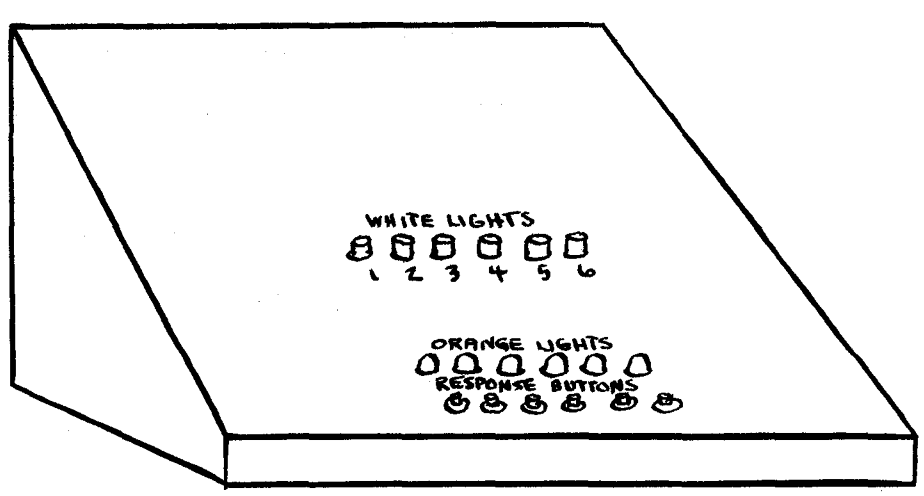

Figure 1. Individual subject panel A, B or C of the General Learning Apparatus.

The six white lights, numbered 1 through 6, the six orange lights and the six response buttons numbered 1 through 6 were used in this experiment. The luminance intensity for the orange and white lights was electrically equal and constant. The onset, offset and duration times for the white and orange lights were pre-programmed and controlled from the console. The inter-trial interval and the seven interstimulus intervals were pre-programmed and controlled from the console.

A five by seven and one-half inch mirror was permanently mounted four feet above and focussed on each subject panel. The mirror was not in the subject's line of vision. The mirrors allowed the experimentor visual access to the subject's activity to determine if the subject was performing according to experimental procedure.

An internal transistor type, model AW (style 90M) Esterline-Angus Event Recorder was used to record the onset of the white lights, the onset and offset of the orange lights, and the onset of individual correct responses. The event recorder was electrically connected to the panels through the console.

A standard door-type, six volt buzzer was used to indicate the transition between test and training phases of the experiment. The buzzer was encased in styrofoam to muffle its' harshness, and was located in the experimental room.

A manually operated modified Esterline-Angus Chart Inspector was used to measure response latency and the number of correct responses. This apparatus measured latency to the nearest 1/100 of one second with an accuracy of plus or minus 1/100 of one second.

A standard General Electric window-type air conditioner in the experimental room ran at high blower speed during experimentation. This established a constant "white" noise to mask extraneous noises from the experimental equipment and the environment.

Procedure

In a delayed classical procedure subjects were instructed to learn six randomized associations between six white lights and six response buttons.

The experiment consisted of two parts, I and II, for each of the seven interstimulus interval groups. Parts I and II were conducted, in that order, in each experimental session. There was a time interval of five to ten minutes between Parts I and II.

Part I

Part I was identical for the seven interval groups, and consisted of 18 orange light presentations; i.e., each of the six orange lights was randomly presented three times. The duration time for the orange light and the inter-trial interval was 4.00 seconds. The subjects' task was to depress the response button directly below the orange light which was on.

Part I, then, served to familiarize subjects with the apparatus and to establish the mode of responding; i.e., depressing the response button under the orange light.

The instructions for Part I were read to the subjects while they observed the panels. A copy of the instructions were then given to each subject to read. The subjects were then given the opportunity to ask questions which were answered by re-reading the pertinent sections of the instructions. The instructions for Part I were as follows:

> There are two (2) parts to this experiment.
>
> PART I OF THE EXPERIMENT WILL WORK LIKE THIS:
>
> 1. When an orange light comes on you are to firmly depress and release the response button directly below it.
> 2. Your task is to respond to each orange light.
> 3. Part I will begin when the buzzer is sounded once and will end when the buzzer is sounded three times.

Part II

This part of the experiment consisted of five test and four training phases in the following sequence: test one, training one; test two, training two; test three, training three; test four, training four; test five.

Test Phases. Each test phase consisted of 12 white light presentations in random order; i.e., each of the six white lights (numbered one to six) was presented twice. The white light duration time and inter-trial time was 4.00 seconds in all test phases for the seven interval groups.

Test phase number one established the subject's ignorance of the white light-response button associations. In test phases two, three, four and five the subjects indicated the white light-response button associations which they had learned during training. The number of correct responses during the test phases served to determine the level of learning.

Training Phases. Each training phase consisted of 18 presentations of the white lights in random order, each followed by an appropriate orange light. Each of the six white lights was presented three times. The orange light which followed each white light signalled the correct response button that the subject was to depress for a correct response. The subject's task during training phases was to learn the white light-response button associations.

In training phases the inter-trial interval was 4.00 seconds for the seven interval groups. The duration time of the orange light was 4.00 seconds in all training phases for all seven interval groups. The duration time of the white light was 4.00 seconds plus the interstimulus interval. The interstimulus interval was the time in seconds between the onset of the white light and the onset of the orange light; i.e., 0.25, 0.50, 1.00, 2.00, 4.00, 8.00 and 16.00 seconds. Both the white and orange lights terminated simultaneously. Operationally, then, this is the delayed classical procedure employed. The white light duration time and the orange light duration time in training phases for the seven interval groups is schematically represented in Figure 2.

The response latency was determined in the training phases. Response latency was the time in seconds between the onset of the white light and the onset of the response.

The instructions for Part II were read to the subjects while they observed their panels. A copy of the instructions was then given to each subject to read. The subjects were then given the opportunity to ask questions which were answered by re-reading the pertinent sections of the instructions. The instructions for Part II were as follows:

> PART II OF THE EXPERIMENT WILL WORK LIKE THIS
>
> 1. Each response button is electrically connected with a different white light.
> 2. Your task now is to learn the correct response button-white light connections.
> 3. You are to indicate your response to each white light by

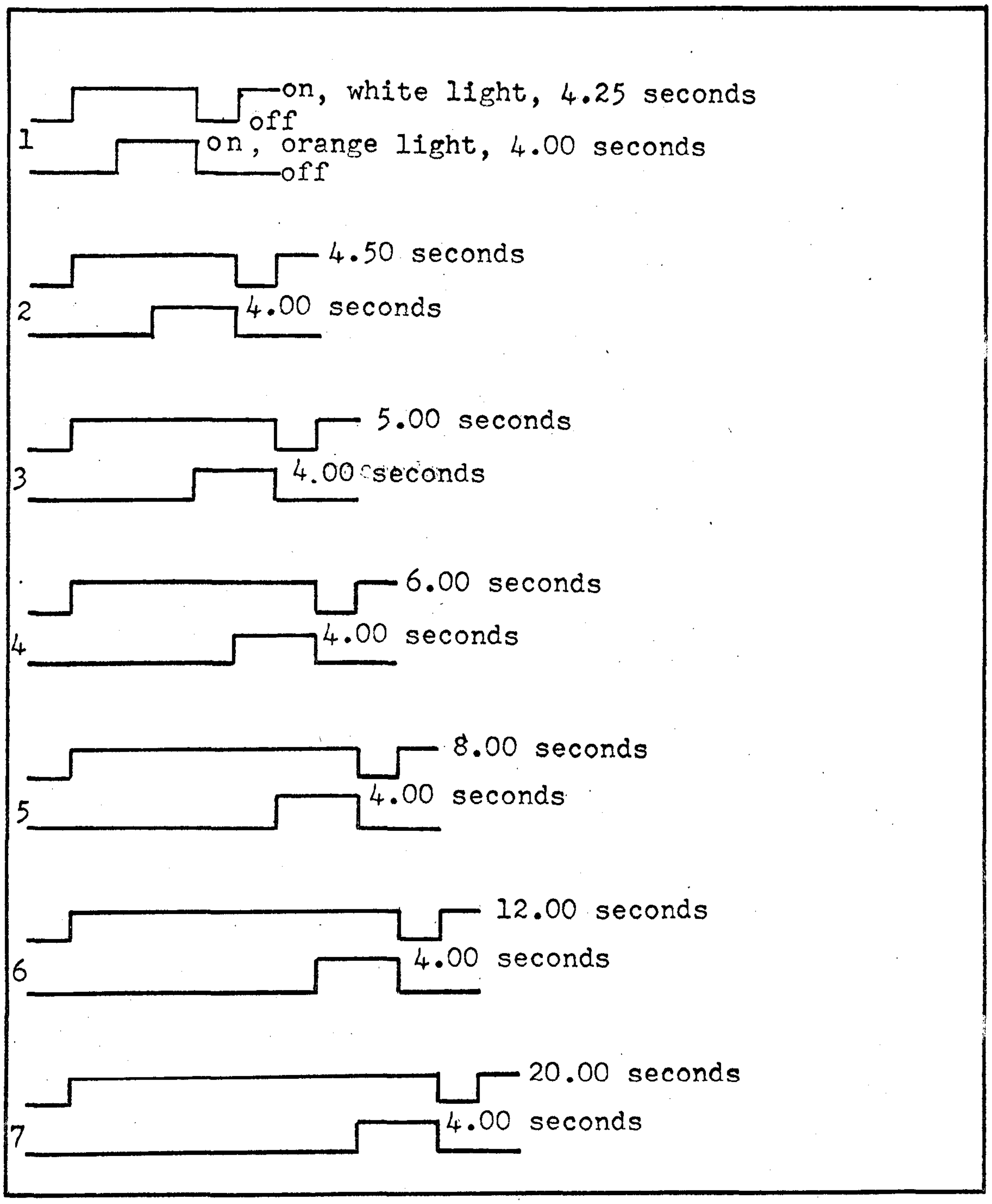

Figure 2. The duration times for the white and orange lights for the seven interstimulus intervals.

firmly depressing and releasing one (1) response button. Please respond to each white light.

4. When an orange light comes on after a white light, this indicates to you the correct response button connection for that particular white light. For example, if white light #3 comes on and then the orange light above response button #3 comes on, this indicates that white light #3 is connected to response button #3.
5. There are two (2) alternating phases, test and train, in this part of the experiment. In test phases you will receive only white lights to respond to. In the training phases you will receive white lights and orange lights. Try to perform as well as possible in both phases.
   a. Test phases will begin when the buzzer is sounded once.
   b. Training phases will begin when the buzzer is sounded twice.

The order in which the six white lights were presented in test and training phases was randomly varied over 36 trials with each white light being presented once out of every block of six trials. This random order of the 36 white lights was constant for the interval group (see Appendix A) and was repeated four times to give the 132 trials required for any one experimental session. This randomization of the white light sequence was to eliminate memorization of the white light and/or response button sequence.

The white light-response button associations were randomly determined and changed for each experimental session. This procedure guarded against the possibility of subjects being informed of the associations previous to participation, by subjects who had already participated. The white light-response button associations used in the 15 experimental sessions are given in Appendix B.

CHAPTER III

RESULTS

The experimental results are presented in two sections. These sections include the level of learning, or the number of correct responses per test block of trials, and response latency.

Level of Learning

The level of learning was determined by the number of correct responses in each of the five test phases for each of the seven interval groups. The maximum level of learning attained by any one interval group would be the highest number of correct responses in that test block. One hundred per cent learning of the six white light-response button associations is 12 correct responses in one test block for any one subject, or 72 correct responses in any one test block for six subjects each making twelve correct responses.

The 0.50 second interval group had the highest level of learning with 72 correct responses in the fourth test block. The second highest level of learning was given by the 1.00 and 4.00 second interval groups with 71 out of 72 correct responses in the fifth test block. The 16.00

second interval group had the third highest level of learning with 70 out of 72 correct responses in the fifth test block. The 0.25 second interval group was fourth with 68 out of 72 correct responses in the fifth test block. The 2.00 second interval group had the fifth highest level of learning with 65 out of 72 correct responses in the fifth test block. The lowest level of learning was demonstrated by the 8.00 second interval group, with 62 out of 72 correct responses in the fourth test block. These results are presented in Table 1.

Table 1

Number of Correct Responses out of 72 for Seven Interstimulus Interval Groups in Five Test Blocks

Groups	Test Blocks				
	1	2	3	4	5
0.25	5	55	66	66	68
0.50	7	41	53	72	70
1.00	7	30	58	62	71
2.00	8	24	34	59	65
4.00	6	32	48	57	71
8.00	5	35	40	62	60
16.00	6	39	63	69	70

The raw scores for the data in Table 1 are presented in Appendix C.

An analysis of variance was done on the data in Table 1 to determine if the differences among the mean number of correct reponses over test blocks and interval groups were significant.

The results of the analysis of variance indicate that the differences in the mean number of correct responses over the test blocks were significant at the 0.01 level, indicating an increase in the level of learning from test block to test block, as shown in Table 2. The variation between intervals was not significant indicating the absence of differences in the level of learning for the seven interval groups. The lack of significance for the interaction factor; i.e., test blocks and interstimulus intervals, again indicates that learning did not vary as a function of the interstimulus interval.

In spite of the lack of significance of the main effect of the interstimulus interval factor, for interest's sake, a further analysis of variance was performed. This main effect was broken down into simple main effects at each stage of learning; i.e., mean number of correct responses for the seven intervals over each of the five test blocks. The analysis indicates that mean number of correct responses between intervals in the second test block varied significantly at the 0.01 level, as shown in Table 3. No differences

Table 2

Analysis of Variance

On the Number of Correct Responses by

Test Blocks for the Interval Groups

Source of Variation	df	MS	F Ratio
Between Subjects	41		
A (Intervals)	6	21.88	2.03
Subjects within Groups	35	10.79	
Within Subjects	168		
B (Test Blocks)	4	733.53	168.24**
AB	24	6.40	1.47
B x Subjects within Groups	140	4.36	
Total	209		

$**F_{.99}(4,120) = 3.48$

Table 3

Analyses of Variance on the Number of Correct Responses

By Test Blocks for the Seven Interstimulus Interval Groups

Test Block	Between Subjects'	Interval Groups''		Residual'''
	MS	MS	F Ratio	MS
1	6.73	.22	.78	.28
2	11.69	16.38	3.58**	4.58
3	24.18	23.26	3.18	7.32
4	17.75	4.86	1.18	4.10
5	3.17	2.47	1.30	2.40
	'df = 5	''df = 6		'''df = 36

$^{**}F_{.99}(6,30) = 3.47$

between interval means for test blocks one, two, three, four and five were significant. These results indicate that there was a significant difference in learning by intervals in the first training blocks but not in succeeding training blocks.

The analysis of variance for differences in the mean number of correct responses over test blocks for each interstimulus interval indicates that they were significant at the 0.01 level for all seven interval groups, as is shown in Table 4. These results indicate that learning for all interval groups was increasing over test blocks.

A trend analysis on correct responses over test blocks was computed to best describe the seven empirical learning curves presented in Figure 3. The analysis indicates that the linear and quadratic components were significant at the 0.01 level, as shown in Table 5. The learning in this experiment, then, is best described by the conventional negatively accelerated learning curve.

A comparison of individual learning by interstimulus intervals shows that all six subjects in the 0.50 and the 1.00 second interval groups reached 100 per cent learning, as shown in Table 6. In each of the 0.25, 4.00 and 16.00 second interval groups five subjects reached 100 per cent learning. In the 8.00 second interval group four subjects, and in the 2.00 second group two subjects reached 100 per cent learning.

Table 4

Analysis of Variance on the Number of Correct Responses

By Test Blocks for the Seven Interstimulus Interval Groups

Interval	Between Subjects' MS	Test Blocks'' MS	Test Blocks'' F Ratio	Residual''' MS
0.25	6.38	93.63	45.90**	2.04
0.50	8.29	100.72	29.75**	3.38
1.00	7.63	101.47	39.48**	2.57
2.00	10.21	85.62	19.07**	4.49
4.00	19.65	86.75	15.75**	5.77
8.00	18.35	69.87	8.96**	7.79
16.00	6.35	104.13	52.06**	2.00
	'df = 5	''df = 4		'''df = 20

$^{**}F_{.99}(4,20) = 4.43$

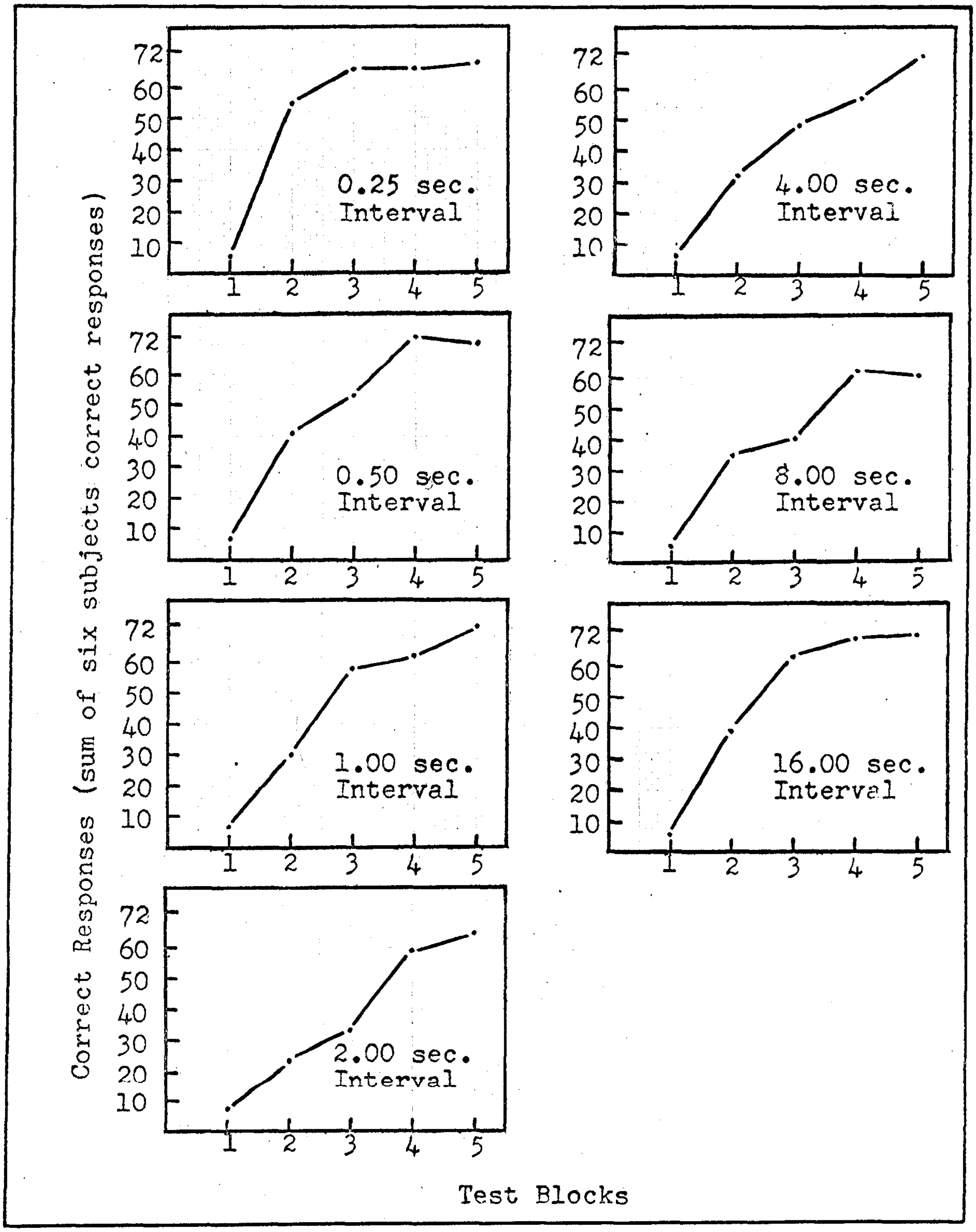

Figure 3. Learning curves for the seven inter-stimulus interval groups.

Table 5

Analysis of Trend on Correct Responses

By Test Blocks

Source of Variation	df	MS	F Ratio
C (linear)	1	2,635.01	634.94**
AC (linear)	6	2.40	
C x subjects within Groups (linear)	35	4.15	
C (quadratic)	1	2.67	46.93**
AC (quadratic)	6	11.38	
C x subjects within Groups (quadratic)	35	5.69	
C (cubic)	1	7.73	2.34
AC (cubic)	6	4.74	
C x subjects within Groups (cubic)	35	3.30	

$^{**}F_{.99}(1,30) = 7.56$

Table 6

Number of Subjects Reaching
100 Per Cent Learning in the Interval Groups

Interval Group	Subjects
0.50	6
1.00	6
0.25	5
4.00	5
16.00	5
8.00	4
2.00	2

Response Latency

Response latency was the time to the nearest 1/100 of one second between the onset of the white light and the onset of the response in training phases. The response latencies for each of the seven interval groups decreased successively from training block number one through block number four, as shown in Table 7 and Figure 4. There was one exception to this finding; viz., the 1.00 second interval showed an increase of 0.07 seconds from the third to the fourth training block. In addition, the mean response latencies in training blocks one through four for the 4.00, 8.00 and 16.00 second intervals were shorter than the interstimulus intervals themselves.

Table 7

Mean Response Latencies in Seconds for the Interval Groups in Training Blocks One Through Four

Interval Group	Training Block 1	2	3	4
0.25	1.66	1.51	1.50	1.24
0.50	1.77	1.67	1.59	1.50
1.00	2.01	1.84	1.61	1.67
2.00	2.97	2.80	2.72	2.27
4.00	3.11	2.31	2.16	1.64
8.00	4.04	3.48	2.77	2.45
16.00	8.70	8.06	5.65	4.77

The analysis of variance computed on the response latencies in Table 7 is shown in Table 8. The analysis indicates that the decrease over training blocks was significant at the 0.01 level. In addition, the increase in latencies over interval groups was significant at the 0.01 level. There was no significant interaction between training blocks and intervals.

A further analysis of variance of training blocks for each interval group is shown in Table 9. These analyses indicate that the decrease in response latencies for the

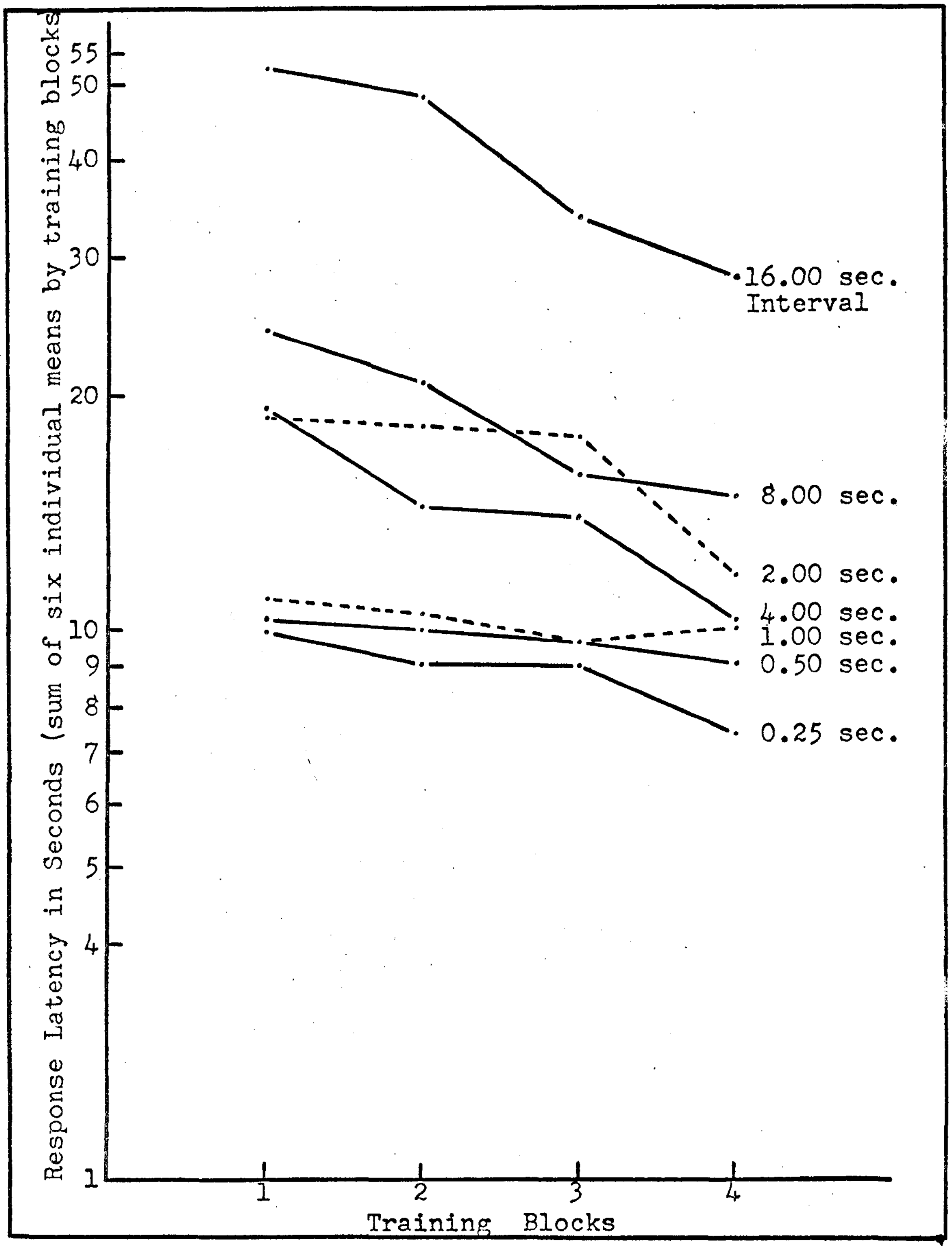

Figure 4. The Response Latency Curves for the Seven Interstimulus Intervals.

0.25 interval group was significant at the 0.01 level while the decreases for the 0.50, 1.00 and 4.00 interval groups were significant at the 0.05 level.

Table 8

Analysis of Variance on Response Latencies by Training Blocks for the Interval Groups

Source of Variation	df	MS	F Ratio
Between Subjects	41		
A (Intervals)	6	78.68	3.90**
Subjects within Groups	35	20.15	
Within Subjects	126		
B (Train. Blocks)	3	12.74	8.33***
AB	18	2.46	1.61
B x Subjects within Groups	105	1.53	
Total	167		

$^{**}F_{.99}(6,30) = 3.47$ $^{***}F_{.99}(3,60) = 4.13$

Analysis of variance of interval groups by training blocks indicates that differences in mean response latency between the seven interval groups were significant in training blocks one and two at the 0.01 level, and in block three at the 0.05 level as shown in Table 10. The differences in mean response latency were not significant in the fourth training block.

Table 9

Analyses of Variance on the Mean Response Latencies by

Training Blocks for the Seven Interstimulus Interval Groups

Interval	Between Subjects' MS	Training Blocks'' MS	Training Blocks'' F Ratio	Residual''' MS
0.25	.62	.20	6.67**	.03
0.50	.22	.08	4.00*	.02
1.00	.61	.19	4.75*	.04
2.00	2.89	.53	.77	.69
4.00	3.81	2.21	4.91*	.45
8.00	6.15	3.04	2.89	1.05
16.00	126.89	21.26	2.55	8.35
	'df = 5	''df = 3		'''df = 15

$^{**}F_{.99}(3,15) = 5.42$ $^{*}F_{.95}(3,15) = 3.29$

Table 10

Analyses of Variance on Mean Response Latencies by the Seven Interstimulus Interval Groups for Training Blocks

Training Block	Between Subjects'	Interval Groups''		Residual'''
	MS	MS	F Ratio	MS
1	7.20	36.34	5.42**	6.70
2	5.83	31.65	6.38**	4.96
3	6.21	12.70	2.66*	4.77
4	4.53	8.71	2.15	4.05
	'df = 5	''df = 6		'''df = 36

$^{**}F_{.99}(6,30) = 3.47$ $^{*}F_{.95}(6,30) = 2.42$

A trend analysis of the mean latencies by training blocks shows that the decrease in mean latency over blocks is best described by a straight line. These data are shown in Table 11.

Table 11

Trend Analysis of Mean Latencies by Training Blocks

Source of Variation	df	MS	F Ratio
C (linear)	1	38.04	11.67**
AC (linear)	6	6.73	
C x Subjects within Groups (linear)	35	3.26	
C (quadratic)	1	.09	.096
AC (quadratic)	6	.06	
C x Subjects within Groups (quadratic)	35	.93	

$^{**}F_{.99}(1,30) = 7.56$

CHAPTER IV

DISCUSSION

Level of Learning

Through analysis of variance the levels of learning established in a delayed classical procedure for seven interstimulus intervals of 0.25, 0.50, 1.00, 2.00, 4.00, 8.00 and 16.00 seconds were found to be not significantly different at the 0.05 level, but only significant at the 0.10 level. This result differs somewhat from previous studies ((Kimble, Mann and Dufort (1955), McAllister (1953), Moeller (1954), Spooner and Kellog (1947), White and Schlosberg (1952) and Wolfle (1932)) where the level of learning was found to decrease significantly with increases in the interstimulus intervals beyond 0.50 seconds. This contrast in results indicates that the effect of the interstimulus interval on learning may depend upon the nature of the response being learned and type of original stimulus employed, i.e., positive versus aversive.

It must be noted, however, that the levels of learning varied significantly in the second test block. In addition, the 0.50 second interval was the only interval in which 100 per cent learning was achieved in any one test phase. On this basis, the 0.50 interval was optimal in this experiment, a result that parallels the conclusions regarding optimal interval drawn from the literature. A further breakdown in the intervals by the number of subjects reaching 100 per cent learning points to the marked inferiority of the 2.00 second interval, where, specifically, only two subjects out of six reached 100 per cent learning. Similar results have been reported by Wolfle (1932) and McAllister (1953). Neither of these authors, nor others have attempted any explanation for the poor performance at the 2.00 second interval. It is possible that this poor performance is an effect of antagonistic mediation processes which produces a tendency not to respond. That is, in the shorter intervals learning follows a predetermined procedure; i.e., the response is given after both the neutral and original stimuli. However, in the longer intervals the procedure calls for a different learning process; i.e., the response may be given between the neutral and original stimuli or after the original stimulus. This change appears to occur somewhere around 2.00 seconds (table 7) because the 2.00 second interval is long enough to allow the mediating process peculiar to the longer intervals to operate, while the process involved in the shorter intervals may also be present. The result due to an interference between the mediators may be a tendency not to respond.

The learning curves for all the interval groups studied fell into one categorey. Performance was best described by the conventional negatively accelerated learning curve. Performance for all intervals followed a similar pattern even though the learning processes, as previously indicated, may be different.

The separate analyses of variance for each of the seven intervals on the number of correct responses over test blocks were significant at the 0.01 level. These results indicate that level of learning was an increasing function over test blocks for all intervals. This result does not agree with Fitzwater and Thrush (1956) and Kimble (1947) who found that the level of learning decreased over test blocks with increases in the interstimulus interval.

Response Latency

It was determined by analysis of variance that the decrease in response latencies over training for the seven interstimulus intervals was significant at the 0.01 level. This result is in the opposite direction to the results of previous investigations where response latency was found to increase over training ((Prokasy, Ebel and Thompson (1963), Rodnick (1937), Spooner and Kellog (1947) and Switzer (1940)). The results of these studies have been interpreted as supporting a "two-factor" contiguity theory (Jones, 1962). This two-factor theory states that contiguity of the stimulus and response are important for learning in early training, and that response-reinforcement contiguity becomes more important in later training. In stimulus-response contiguity the response becomes associated with the stimulus. In response-reinforcement contiguity the response becomes associated with the reinforcement but not with the stimulus. The significant decrease in latencies over training in the present experiment indicates that contiguity of the stimulus-response may be more important throughout learning. This finding is in agreement with Guthrie (1952) and Razran (1957).

The separate analyses of variance for each of the seven intervals, over training, indicated, however, that the decrease in latencies for the 2.00, 8.00 and 16.00 second intervals was not significant at the 0.05 level. The decrease for the 0.25 second interval group was significant at the 0.01 level, and at the 0.05 level for the 0.50, 1.00 and 4.00 second intervals. The lack of significant decrease over training for the 2.00, 8.00 and 16.00 second intervals was due to the high variability between subjects.

The increases in response latency with increases in the interstimulus intervals were significant at the 0.01 level. Similar results have been presented in previous studies, e.g., Prokasy, Ebel and Thompson (1963) and Spooner and Kellog (1947).

In general, it was felt that the present study does not support the theory that the level of learning decreases with increases in interstimulus time beyond 0.50 seconds. The study may support the theory of a possible mediation conflict in accounting for the inferiority of the 2.00 second interval in this and other studies. The relavence of this theory depends on the type of learning being studied and the type of stimuli employed. In addition this study tends to support a stimulus-response contiguity theory.

Suggestions for Further Research

In that the results of this experiment, which deals with higher order learning using positive informational stimulation, are not generally in agreement when compared with previous results it is recommended that:

1) The present study be replicated using a trace classical procedure;

2) The present study be replicated using backward trace and backward delayed procedures;

3) A study employing a simultaneous procedure be done.

These recommendations, then, together with the present study would give a clearer and more comprehensive understanding of the relationship holding between interstimulus interval time and individual human learning.

CHAPTER V

SUMMARY

The problem in the present study was to investigate the effect of the interstimulus interval on individual human learning through a delayed classical procedure. Seven interstimulus intervals were employed; 0.25, 0.50, 1.00, 2.00, 4.00, 8.00 and 16.00 seconds.

Forty-two male undergraduate, monolingual students participated in the experiment. The General Learning Apparatus of the department of Psychology, University of Windsor was used. All subjects were instructed to learn six randomized associations between six white lights and six response buttons. The experiment consisted of two parts for all interstimulus intervals. Part I was to familiarize the subjects with the apparatus and to extablish the mode of response. In Part II five test and four training blocks were alternately presented. The level of learning was measured over test blocks, and response latency was measured over training blocks.

The results indicate that the maximum levels of learning attained in four test blocks by the seven interval groups were not significantly different. From the point of view of learning to criterion of the experimental task it was found that the 0.50 second interval group was superior, and the 2.00 second interval group markedly inferior, to the other intervals studied.

The results show that response latency increased consistently with increases in the interstimulus interval time. In addition, response latency decreased over training monotonically.

APPENDIX A

Random Order of Presentation of Thirty-six White Lights

1.	2	19.	4
2.	4	20.	3
3.	5	21.	1
4.	3	22.	2
5.	1	23.	6
6.	6	24.	5
7.	1	25.	4
8.	4	26.	1
9.	3	27.	3
10.	5	28.	6
11.	6	29.	2
12.	2	30.	5
13.	6	31.	6
14.	5	32.	4
15.	4	33.	3
16.	3	34.	1
17.	2	35.	5
18.	1	36.	2

APPENDIX B

White Light-Response Button Connections Used in the Fifteen Experimental Sessions

No.	White Light	Resp. Button	No.	White Light	Resp. Button	No.	White Light	Resp. Button
1.	1	6	6.	1	6	11.	1	4
	2	1		2	5		2	6
	3	4		3	4		3	5
	4	5		4	1		4	2
	5	2		5	3		5	1
	6	3		6	2		6	3
2.	1	3	7.	1	5	12.	1	6
	2	5		2	4		2	3
	3	4		3	6		3	1
	4	6		4	1		4	5
	5	2		5	3		5	2
	6	1		6	2		6	4
3.	1	5	8.	1	4	13.	1	5
	2	4		2	3		2	3
	3	6		3	5		3	6
	4	1		4	1		4	1
	5	3		5	6		5	2
	6	2		6	2		6	4
4.	1	3	9.	1	3	14.	1	4
	2	5		2	4		2	1
	3	6		3	1		3	5
	4	1		4	6		4	6
	5	4		5	2		5	2
	6	2		6	5		6	3
5.	1	4	10.	1	5	15.	1	3
	2	6		2	1		2	6
	3	5		3	4		3	4
	4	2		4	6		4	1
	5	3		5	3		5	2
	6	1		6	2		6	5

APPENDIX C

Correct Responses in Test Blocks for the Seven Intervals

Intervals	Subject	Test Blocks 1	2	3	4	5
0.25	1	0	8	11	12	12
	2	3	9	12	12	12
	3	1	12	12	12	12
	4	0	9	8	8	8
	5	0	12	12	11	12
	6	1	5	11	11	12
0.50	7	2	7	9	12	12
	8	0	5	4	12	12
	9	4	4	5	12	10
	10	0	12	12	12	12
	11	1	5	11	12	12
	12	0	8	12	12	12
1.00	13	1	4	10	12	12
	14	0	6	12	12	12
	15	1	6	12	11	12
	16	4	4	9	12	11
	17	1	6	10	11	12
	18	0	4	5	4	12
2.00	19	0	1	9	12	12
	20	3	9	9	8	11
	21	2	3	4	7	10
	22	1	5	7	12	11
	23	0	6	5	11	11
	24	2	0	0	9	10

Appendix C continued.

	25	1	6	10	12	12
	26	1	2	9	11	12
4.00	27	0	7	6	12	12
	28	2	9	12	12	12
	29	0	6	9	10	11
	30	2	2	2	0	12
	31	1	5	7	12	12
	32	2	4	8	10	11
8.00	33	0	5	11	12	12
	34	0	5	12	11	11
	35	0	9	2	12	12
	36	2	7	0	5	2
	37	1	6	12	10	12
	38	3	8	10	12	12
	39	1	8	12	12	11
16.00	40	0	8	12	12	12
	41	0	7	12	12	12
	42	1	2	5	11	11

APPENDIX D

Mean Response Latencies in Training Blocks for the Seven Intervals

Intervals	Subject	Training Blocks 1	2	3	4
0.25	1	1.09	.92	.83	.87
	2	1.67	1.49	1.37	1.42
	3	1.43	1.08	1.04	.90
	4	2.01	2.17	2.08	1.60
	5	1.68	1.57	2.07	1.10
	6	2.11	1.83	1.62	1.55
0.50	7	1.84	1.69	1.65	1.56
	8	1.95	2.01	2.14	1.80
	9	1.94	1.95	1.84	1.55
	10	1.62	1.45	1.44	1.51
	11	1.88	1.43	1.30	1.37
	12	1.40	1.51	1.20	1.22
1.00	13	1.76	1.87	1.41	1.26
	14	2.01	1.97	1.62	1.87
	15	2.73	2.07	1.80	1.90
	16	1.79	1.76	1.69	1.53
	17	1.50	1.18	1.10	.93
	18	2.26	2.19	2.05	2.53
2.00	19	1.06	3.25	1.70	1.70
	20	1.47	1.13	1.68	1.10
	21	3.16	3.13	3.93	2.47
	22	3.17	3.30	3.47	3.03
	23	5.43	2.51	2.08	2.08
	24	3.51	3.51	3.51	3.26

Appendix D continued.

4.00	25	3.17	2.26	1.71	1.84
	26	6.44	4.32	4.20	1.92
	27	2.77	1.93	1.68	1.70
	28	2.47	2.16	1.62	1.33
	29	2.13	1.82	2.35	1.80
	30	1.66	1.38	1.43	1.25
8.00	31	8.15	5.87	4.96	2.24
	32	3.70	2.98	2.41	1.95
	33	2.33	1.79	1.05	1.48
	34	3.45	3.06	2.65	2.62
	35	4.12	4.48	2.26	4.29
	36	2.48	2.71	3.29	2.15
16.00	37	4.72	3.59	2.52	3.20
	38	17.58	13.28	3.54	3.27
	39	3.74	3.03	1.70	2.19
	40	17.04	16.95	16.94	16.50
	41	3.45	2.39	1.28	1.24
	42	5.67	9.44	7.90	2.26

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